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Modelling the distribution of the Great scallop *Pecten maximus* in the English Channel: linking physical and biological processes to define scallop habitat.

Philippe. Cugier[1], *Clément Legoff*[1], *Romain Lavaud*[2], *Frédéric Jean*[2], *Jonathan Flye-Sainte-Marie*[2], *Eric Foucher*[3], *Spyros Fifas*[4]

(1) Ifremer, ODE/DYNECO/ Laboratoire d'Ecologie Benthique, 29280 Plouzané, France. (2) Université de Bretagne Occidentale, Institut Universitaire Européen de la Mer, Laboratoire des sciences de l'environnement marin (UMR CNRS 6539), Plouzané , France. (3) Ifremer, RBE/HMMN/ Laboratoire de Ressources Halieutiques, Port en Bessin, France. (4) Ifremer, RBE/STH/ Laboratoire de Biologie Halieutique, Plouzané, France. Presenter contact details : pcugier@ifremer.fr, Phone +33 298 22 49 19, Fax +33 298 22 45 48

Summary

The great scallop *Pecten maximus* is currently the most important species in landings (as well in tons as in value) for the French inshore fleet of the English Channel. A modelling approach has been proposed in order to better understand the determinism of the distribution of the great scallop, integrating both physical and trophic constraints. Thus a 3D bio-hydrodynamical model (ECOMARS3D developed at Ifremer) providing environmental conditions has been coupled to a population dynamics model and an individual physiological model of scallop. Both these approaches contribute to the understanding of the biogeographical distribution and especially enlighten the respective role of biological or physical factors in defining *P. maximus* habitat in the English Channel.

Introduction

Understanding the spatial distribution and abundance of marine benthic exploited species is of prime importance as well as for ecological and scientific reasons than for fisheries management. Many processes are involved in the explanation of a benthic species habitat (hydrodynamic, sediment, physiology, ecology,…) and have to be take into account simultaneously. Numerical models appear to be powerful tools of integration for processes of such different nature and time scale and are used in this study to simulate the distribution and abundance of the great scallop *Pecten maximus.*

Materials and Methods

This study is based on the development and the coupling of 4 models. The first one (M1) is the hydrodynamic MARS 3D model (Lazure and Dumas, 2008) which is used to compute all the physical properties in the English Channel: temperature, salinity, tide, current velocities. The horizontal spatial resolution is 2 kilometers and the vertical is divided into 10 sigma layers. It is coupled to a NPZD primary production model (M2) to simulate ecosystem properties. It takes account of nutrients (nitrate, ammonium, phosphate, silicates), 3 phytoplankton groups (diatoms, dinoflagellates, nanophytoplankton) as well as 2 zooplankton sizes (micro and mesozooplankton). The third model (M3) is a population model for the scallop describing the whole life cycle (planktonic and benthic) using a mechanistic approach (based on Savina & Ménesguen, 2008). It is structured in age classes and described the dynamics of the density of each age class. Dispersion of larvae and recruitment of adults are conducted by hydrodynamics. Mortality, fecundity and growth are parameters respective to this species. The fourth model (M4) is an ecophysiological model based on the Dynamic Energy Budget (DEB) Theory (Kooijman, 2000) and adapted to the scallop (Lavaud et al., submitted). It allows simulating individual growth, fecundity and physiological status.

Results and Discussion

The scallop distribution is modelled by coupling M1 and M3. Simulation starts with an uniform concentration of adults (3 years old) in the whole domain and a stationary state is reached after approximately 20 years. Some patterns (Figure 1) are easily recognisable between sea campaigns (left) and simulated distribution (right) and the main features of the distribution are captured. Thus, population dynamic characteristics and physical constraints seem to be able to explain most of the presence-absence of *Pecten maximus* in sea channel.

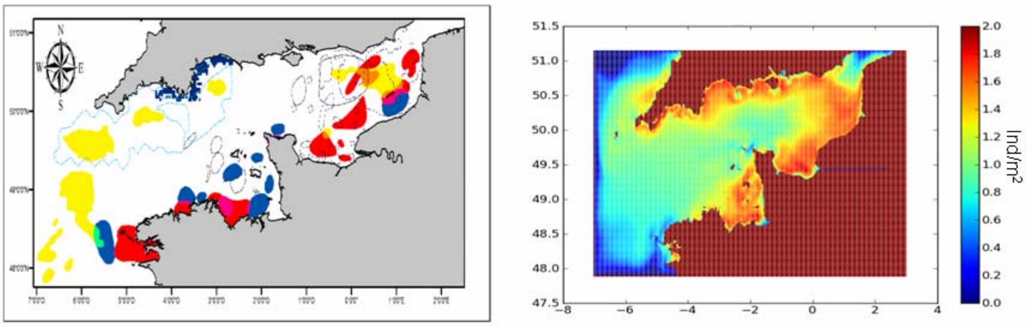

Figure 1: Map of scallop presence in the channel (left) and computed distribution of scallop (ind.m^{-2}) obtained after 30 years of simulation (right).

To simulate the scallop growth is the Channel, model M1, M2, and M4 were coupled. Bottom temperature and chlorophyll *a* computed with the NPZD model in each mesh of the domain are provided to the scallop DEB model in order to simulate the potential growth. Simulated growth curves obtained in 2 areas of the Bay of Seine (French coast of the English Channel) are compared with in situ data of the same areas (Figure 2). A good fitting is obtained and the model seems to be able to simulate the scallop growth over several years. Mapping the scallop weight obtained after 5 years of simulation (Figure 2) gives an idea of the potential growth all over the channel.

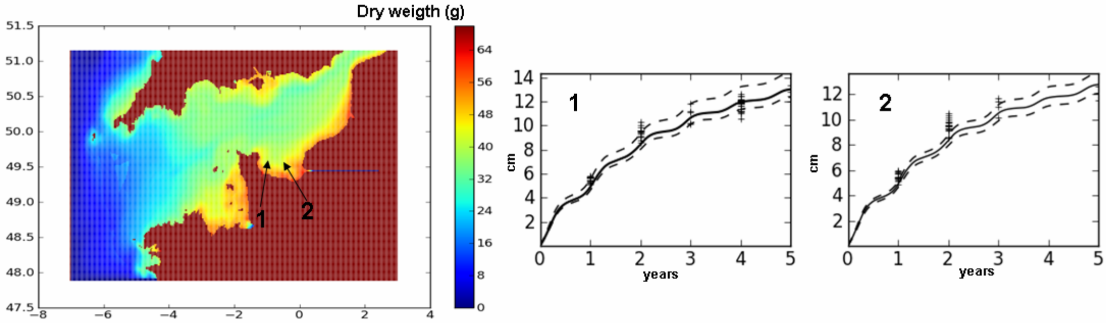

Figure 2: Map of computed dry weight after 5 years of simulation and comparisons between measured (crosses) and simulated (lines) scallop length in 2 areas of the bay of Seine.

The use of these two complementary approaches, the first one based on population dynamic and physical mechanisms, the second one on a physiological approach linked to trophic resource give interesting informations about processes explaining the known distribution. The next step will be now to explicitly connect all these models. Thus, the ecophysilogical model, by linking environmental conditions to physiological status of individuals, will provide informations about individual fecundity and mortality which will be used as parameters in the dynamic population model.

References

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